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6. AUTHOR(S)
Brent S. Stewart, Ph.D., J.D.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Hubbs-Sea World Research Institute
2595 Ingraham Street
San Diego, CA 92109

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13. ABSTRACT *(Maximum 200 words)*

Nine species of marine mammals were evaluated to determine the intraspecific variation in the affinity of hemoglobin for oxygen under varying conditions of pH and temperature. A typical sigmoidal curve of oxygen saturation versus partial pressure of oxygen was found in all species under each condition tested. This curve was shifted to the right in pinnipeds (harbor seals, California sea lions, northern elephant seals) relative to cetaceans (common dolphin, Pacific white-sided dolphin, Commerson's dolphin, bottlenose dolphin, killer whale), indicating a lower affinity of hemoglobin for oxygen in the former. The affinity of hemoglobin for oxygen was greater in the smaller species of odontocete cetaceans (common dolphin, Commerson's dolphin, Pacific white-sided dolphin). It increased substantially with temperature in sea lions and elephant seals but not in harbor seals or the cetaceans and decreased with decreasing pH (Bohr effect) in all species. Overall, the hemoglobin of phocid pinnipeds, which are known to be long and deep breath-hold divers, was generally lower than in the other species. These characteristics are evidently adaptations which promote the unloading of oxygen to the tissues at the end of a long dive, when oxygen stores are depleted, in the former species whereas they allow rapid loading of oxygen at the surface during the brief but frequent surface periods of the latter species.

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FINAL REPORT

GRANT #: N00014-94-1-0814

PRINCIPAL INVESTIGATOR: Brent S. Stewart, Ph.D., J.D.

INSTITUTION: Hubbs-Sea World Research Institute

GRANT TITLE: Effects of temperature and pH on the dynamics of hemoglobin-oxygen binding properties in marine mammals

AWARD PERIOD: 1994-1996

OBJECTIVE: To investigate the effects of pH and temperature on the binding dynamics of hemoglobin and oxygen in marine mammals which are known to vary substantially in diving and swimming performance.

APPROACH: Blood samples were collected from free-ranging and captive marine mammals and the affinity of hemoglobin for oxygen was determined under a variety of pH and temperature conditions using biotonometry.

ACCOMPLISHMENTS: Nine species of marine mammals were evaluated to determine the intraspecific variation in the affinity of hemoglobin for oxygen under varying conditions of pH and temperature. A typical sigmoidal curve of oxygen saturation versus partial pressure of oxygen was found in all species under each condition tested. This curve was shifted to the right in pinnipeds (harbor seals, California sea lions, northern elephant seals) relative to cetaceans (common dolphin, Pacific white-sided dolphin, Commerson's dolphin, bottlenose dolphin, killer whale), indicating a lower affinity of hemoglobin for oxygen in the former. The affinity of hemoglobin for oxygen was greater in the smaller species of odontocete cetaceans (common dolphin, Commerson's dolphin, Pacific white-sided dolphin) than in the larger species (bottlenose dolphin, killer whale). The affinity of hemoglobin for oxygen increased substantially with temperature in California sea lions and northern elephant seals but not in harbor seals or the cetaceans. The affinity of hemoglobin for oxygen decreased with decreasing pH (Bohr effect) in all pinnipeds and cetaceans.

CONCLUSIONS: The affinity of hemoglobin for oxygen was generally lower in pinnipeds compared with odontocete cetaceans. It

decreased in all species when pH was reduced to 7.2 and in elephant seals and California sea lions when temperature was lowered to 33°C. The affinity of hemoglobin for oxygen was insensitive to changes in temperature in harbor seals and cetaceans. Overall, the hemoglobin of phocid pinnipeds, which are known to be long and deep breath-hold divers, was generally lower than in the other species. These characteristics are evidently adaptations which promote the unloading of oxygen to the tissues at the end of a long dive, when oxygen stores are depleted, in the former species whereas they allow rapid loading of oxygen at the surface during the brief but frequent surface periods of the latter species.

SIGNIFICANCE: These studies have provided substantial new data on the function of oxygen binding molecules in a variety of marine mammal species and yielded insights into the adaptations of these species for exploiting various marine habitats.

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